EFFECT OF ORGANIC & BIOFERTILIZER ON THE GROWTH OF PATCHOULI PLANT (*Pogostemon cablin*)

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A thesis submitted in fulfilment of the requirements for the award of the degree of Bachelor of Chemical Engineering (Biotechnology)

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APRIL 2008

I declare that this thesis entitled

"EFFECT OF ORGANIC & BIOFERTILIZER ON THE GROWTH OF PATCHOULI PLANT (*Pogostemon cablin*)"

is the result of my own research except as cited in references.

The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :……

Name of Candidate : Ahmad Farhan bin Md. Shokeri

Date : 16 APRIL 2008

DEDICATION

Special dedication of this grateful moment to my...

Beloved parents;
Md. Shokeri bin Md. Zin
Siti Zalikhoo binti Hj. Abd. Ghani

Loving family member;
Ahmad Farizal bin Md. Shokeri

That always loves me,
My friends, my fellow colleague
and all faculty members

For all your Care, Support and Believe in me.

ACKNOWLEDGEMENT

Assalamualaikum…

For the success of this thesis I owe it to my supervisor Miss Wan Salwanis binti Wan Md Zain. Therefore I would like to take this opportunity to extend my deepest gratitude to her. Without her guidance, support, continuous patience and supervision this thesis would not be accomplished successfully. Her steadfast approach and never let down attitude has inspired me to work much even harder.

Further gratitude goes to my lecturers and teaching engineers, for their guidance and coordination in this thesis. To other master students who have taken effort in guiding me, you all deserve sincere thank from me.

Last but not least, my fellow colleagues who were kind of companion during rough times completing this thesis. I extend my sincere gratitude for all the help and guidance that I have received.

Wassalam

ABSTRACT

Patchouli was first described by botanists in the Philippines in 1845. Today growing interest in its fragrance has led to patchouli's widespread cultivation throughout tropical Asia. The research is focused on the growth of patchouli plant (*Pogostemon cablin*) and its essential oil production. The objective of this research is to study the effect of organic and biofertilizer on the growth of patchouli plant (*Pogostemon cablin*). All the fertilizer that was used in this research was analyzed to determine it characteristic using DR 2800 Spectrophotometer (HATCH) and Polarized Zeeman Atomic Absorption Spectroscopy (HITACHI). There were 28 patchouli plants was used in this research and hydro distillation was proposed to extract it essential oil. Patchouli oil accounted for about 2-3% of the patchouli dried leaves. The growth of plant had no significant affected by types of fertilizer. However the highest yield of oil was observed at 1.231 g/g using biofertilizer, which is 155% increase compared to control.

ABSTRAK

Patchouli telah di perkenalkan buat pertama kalinya oleh seorang ahli botani dari Filipina pada tahun 1845. Kini perkembangan minat terhadap keharumannya telah menyebabkan penanaman terhadap patchouli telah tersebar luas ke segenab Asia Tropika. Kajian yang di jalankan ini adalah tertumpu kepada mengkaji kadar pertumbuhan pokok patchouli (*Pogostemon cablin*) dan juga pati minyaknya. Objektif kajian ini adalah untuk mengkaji kesan penggunaan baja organik serta baja biologikal terhadap pertumbuhan pokok patchouli (*Pogostemon cablin*). Kesemua jenis baja yang di gunakan dalam kajian ini akan di analisis terlebih dahulu untuk mengetahui ciri-ciri isi kandungannya dengan menggunakan *DR 2800 Spectrophotometer (HATCH)* dan juga *Polarized Zeeman Atomic Absorption Spectroscopy (HITACHI)*. Terdapat 28 pokok patchouli yang di gunakan dalam kajian ini dan proses penyulingan berair di gunakan untuk mengekstrak keluar pati minyaknya. Minyak patchouli adalah kira-kira 2-3% daripada jumlah asal berat kering daun patchouli. Kadar pertumbuhan pokok hampir tidak di pengaruhi oleh jenis baja yang di gunakan. Walaubagaimanapun, hasil minyak terbanyak di perolehi menggunakan baja biologikal, iaitu 1.231 g/g, melebihi 155% daripada kawalan.

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LIST OF SYMBOLS/ABBREVIATIONS

ADP	-	adenosine diphosphate
ATP	-	adenosine triphosphate
cm	-	centimeter
DNA	-	deoxyribonucleic acid
g	-	gram
in	-	inch
kg	-	kilogram
L	-	liter
m	-	meter
mg/kg	-	milligram per kilogram
mg/L	-	milligram per Liter
min	-	minute
mL	-	milliliter
mL/min	-	milliliter per minute
mm	-	millimeter
pH	-	hydrogen ion concentration
RNA	-	ribonucleic acid
TKN	-	Total Kjeldahl Nitrogen
%	-	percentage
ºC	-	degree Celcius
µm	-	micrometer
º/min	-	degree per minute

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Patchouli is native to tropical Asian regions and was widely used incense, perfumes and insect repellents. The west's introduction to patchouli began early in the 19th century when fascination grew about the layers of crushed herb sprinkled liberally in shipments of carpets, fabrics and clothing imported from India and the Middle East. The dried leaves were not placed for aesthetic purposes but as insect repellent, a use for which the east had always used patchouli. Patchouli became the signature scent of the hippie generation of the 1960's where it was used to mask the tarry odour of marihuana. The scent of patchouli is heavy and strong. It has been used for centuries in perfumes, and is grown in the East and West Indies. The word derives from the Tamil language, patchai (green) and ellai (leaf) [1].

The patchouli plant is a bushy herb reaching two or three feet in height and it grows well in southern climates. It enjoys hot weather but not direct sunlight [1]. If the plant withers due to lack of watering it will recover well and quickly once it has been watered. The seed-bearing flowers are very fragrant and bloom in late fall. The tiny seeds may be harvested for planting, but they are very delicate and easily crushed. Cuttings from the mother plant can also be rooted in water to produce further plants.

Patchouli is usually grown on small forest plots by individual farmers who harvest and dry the leaves, then sell them to distilleries throughout the growing

region. The still operators buy many lots of dried leaves and combine them into one steam distillation, the results of which may then be combined with successive distillations until they've obtained sufficient quantities of oil. Newly distilled patchouli oil has a fresh, green, slightly harsh aroma. As the oil ages it mellows considerably, becoming sweeter and more balsamic. Patchouli is one of very few oils that, like fine wine, improve with age. High quality patchouli oils emit a suave, fruity, wine-like top note when uncapped. Other oils that age well are sandalwood and vetiver, both of which blend quite nicely with patchouli.

Patchouli is most often used in aromatherapy. In aromatherapy patchouli is often used as a relaxant. The warmth and depth of its aroma make it comforting and relaxing. Patchouli's relaxing attributes, coupled with its rich and exotic nature, have led to its inclusion in sensual and amorous blends, particularly appropriate for products like massage oil.

In the process of plant the patchouli, it should have to provide optimum nutrients to the patchouli plant to growth well. To protect the environment from any side effect, it is safe to use the organic fertilizer and biofertilizer than a chemical fertilizer.

Organic fertilizers differ from chemicals fertilizers in that they feed the plants while adding organic material to the soil. Soils with lots of organic matter remain loose and airy, hold more moisture and nutrients, foster growth of soil organisms, and promote healthier plant root development. On the other hand, application of chemical fertilizer resulted in loses of organic matter and microbiotic activity. As organic matter is used up, the soil structure deteriorates, becoming compact, lifeless and less able to hold water and nutrients.

Biofertilizers are the most advanced bio technology necessary to support developing organic agriculture, sustainable agriculture, green agriculture and non-pollution agriculture. This biofertilizer can increase the output, improve the quality and it is responsible for agriculture environment [2]. It is well known that the

continue use and overuse of petrochemical based fertilizers and toxic pesticides have caused a detrimental effect to the soils, water supplies, foods, animals and even people. Biofertilizer contains a wide range of naturally chelated plant nutrients and trace elements, carbohydrates, amino acids and other growth promoting substances. Kelp acts as a soil conditioner by stimulating microbial activity in the soil which results in improved air-water relationships in soil, improved fertility and makes soil less prone to compaction and erosion.

1.2 Problem Statements

After the introduction of chemical fertilizers in the last century, farmers were happy for the increase of yield in agriculture. But slowly, chemical fertilizers is showing their ill-effects such as leaching out, and polluting water basins, destroying micro-organisms and friendly insects, making the crop more susceptible to the attack of diseases, reducing the soil fertility and thus causing irreparable damage to the overall system.

A number of intellectuals throughout the world started working on the alternatives and found that biofertilizers can help in increasing the yield without causing the damage associated with chemical fertilizers.

Biofertilizer, the name itself is self explanatory. The fertilizers are used to improve the fertility of the land using biological wastes, hence the term biofertilizers, and biological wastes do not contain any chemicals which are detrimental to the living soil. They are extremely beneficial in enriching the soil with those micro-organisms, which produce organic nutrients for the soil and help combat diseases. The farm produce does not contain traces of hazardous and poisonous materials. Thus those products are accepted across the world as organic ones.

1.3 Objective

The objective of this research is to study the effect of organic and biofertilizer on the growth of patchouli plant (*Pogostemon cablin*) and essential oil yield.

1.4 Scope of Study

The scopes for this study were:

i. To characterize of organic and biofertilizer
ii. To study the effect of various fertilizer on the growth of patchouli plant
iii. To optimize the dosage fertilizer of the growth of patchouli plant
iv. To extract essential oil using steam distillation method.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

There is increasing concern regarding environmental problems related to fertilizers, as they can be a major source of non-point source pollution in soils and waters. Eutrophication, NO_3 contamination of groundwater, and the accumulation of heavy metals in soil and their release to waters, together with their potential bioaccumulation in the food chain, are among the main problems [3].

Although fertilizers provide nutrients to crops, they can contain elements, such as heavy metals, that are potentially harmful for the environment. In most cases, legislation regarding fertilizer composition affects only label statements concerning the nutrient contents, but does not regulate the concentration of other elements. In recent years, some countries have set tolerance limits for some elements [3].

Patchouli (*Pogostemon cablin*) oil is one of the important natural essential oils used as a base and provides lasting character to fragrance in perfumery industry. The dry leaves of patchouli on steam distillation yield an essential oil called the oil of patchouli. Indonesia is the major producer of patchouli oil in the world with an estimated 550 tons per year, which is more than 80% of the total [4].

2.2 Patchouli Plant (*Pogostemon cablin*)

2.2.1 Patchouli Historical

During the 18th and 19th century silk traders from China traveling to the Middle East packed their silk cloth with dried patchouli leaves to prevent moths from laying their eggs on the cloth. Many historians speculate that this association with opulent eastern goods is why patchouli was considered by Europeans of that era to be a luxurious scent. This trend has continued to the present day in modern perfumery [5].

The patchouli plant is a fragrant herb, native to tropical Asia and is cultivated in India, Indonesia, Malaysia, the Philippines and Singapore. It grows from 2 to 3 feet in height, and bears egg-shaped leaves, along with whitish flowers, tinged with purple. Harvested two or three times a year, the leaves are then dried in preparation of distillation [6].

Distillation produces thick oil, amber to dark orange in color, with a powerful, earthy sweet, somewhat musty, unmistakable fragrance - that improves as it ages. The plant and oil have a number of claimed health benefits in herbal folk-lore, and its scent is used with the aim of inducing relaxation.

The patchouli plant is a bushy herb reaching two or three feet in height. It grows well in southern climates and enjoys hot weather but not direct sunlight. If the plant withers due to lack of watering it will recover well and quickly once it has been watered. The seed-bearing flowers are very fragrant and bloom in late fall. The tiny seeds may be harvested for planting, but they are very delicate and easily crushed. Cuttings from the mother plant can also be rooted in water to produce further plants [5].

Patchouli	
	
Scientific classification	
Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Lamiales
Family	Lamiaceae
Genus	*Pogostemon*
Species	*P. cablin*
Binomial name	
Pogostemon cablin	

Figure 2.1: Scientific classification of patchouli

Patchouli is a tropical member of the mint family, grown in the East and West Indies. Leaves are harvested several times a year, dried, and exported for distillation of the oil, although the highest quality oil is usually produced from fresh leaves, distilled close to the plantation.

2.2.2 Morphology Characteristic

Patchouli is one of the herbal plants. Patchouli is categorizing as a small plant with a lot of branch and can growth about 1.0 m height. It has a leaves with oval shape, thick, jagged around it and dark green in color. Pressing and squeezing the patchouli leaves will produce a unique aroma. Patchouli stem and branch appear as a purple in color, square in shape and covered by soft fur.

Flower spikes of clusters of very tiny, pink lip flowers form on axillary and terminal stems. As the flowers fade, the fine, brown seeds form in small capsules, which look like tiny knots on the spike. Leaves, flowers and seeds freely give off their aroma, but even more so if crushed between the fingers. When the stems are cut, their aroma will permeate the room as they dry [7].

2.2.3 Patchouli Species

2.2.3.1 *Pogostemon cablin*

This species are easily can found in Brazil, Philippine, Malaysia, Madagascar and also Indonesia. *Pogostemon cablin* has the heart shape leaves and have furry under it leaves. Normally, this species of Patchouli are not contains a flower and can be produce about 2.5 - 5% of oil.

2.2.3.2 *Pogostemon heyneanus*

Pogostemon heyneanus is another species of Patchouli plant. This species are normally found in a jungle and also in small bushes. Because of that, this species are classified as a wild plant and peoples in Malaysia called it as ‘Nilam hutan’. It has thin and also a sharp shape of leaves. Different from *Pogostemon cablin* species, *Pogostemon heyneanus* species have a flower. Extraction of *Pogostemon heyneanus*

can only produce about 0.5 - 1.5% of extraction oil. Moreover, the oil produced is low in quality compared to oil from *Pogostemon cablin*.

2.2.3.3 *Pogostemon hortensis*

The leaves of *Pogostemon hortensis* species have the same characteristic with the *Pogostemon heyneanus* and the difference is that this species does not flower. This species of Patchouli plant also have a low quality of it extraction oil and only can produce about 0.5 - 1.5% of extraction oil.

2.2.4 Special Properties and Effectiveness

2.2.4.1 Medical Use

Patchouli oil has had a long history of medicinal use in India, China and Japan. Patchouli has a sweet spicy aroma, with a hint of musk, used to stimulate the nervous system, lift depressed moods, relieve stress and give a feeling of elation and wellbeing. Patchouli is believed to help balance the endocrine system, which in turn balances the hormones of the body. The aroma assists the body to relax and promotes a feeling of peace. It also stimulates the pituitary gland, which secretes endorphins, which are known for their ability to relieve pain and induce euphoria as well as sexual feelings. Just sniffing the fresh leaves can give a feeling of rejuvenation when feeling worn out [7].

2.2.4.2 Aromatherapy Use

Patchouli essential oil is used as a topical remedy for skin problems such as acne, eczema, inflamed, cracked, chapped and irritated skin. It is known as a cell rejuvenator and helpful in healing wounds and scars. As an antifungal, patchouli oil

has been used to treat athlete's foot. For the hair, patchouli oil has been used for dandruff and to aid oily hair.

For the nervous system, patchouli essential oil helps to reduce tension, insomnia and anxiety. It is also know as uplifting fragrance that helps to soothe away everyday cares, and to bring about a sense of nourishment. In this way, and due to its wine-like intoxicating aroma, patchouli oil is also known as an aphrodisiac [8].

2.2.4.3 Spiritual Use

Patchouli is used in temples as incense. It is said to assist in grounding and centering the mind prior to meditation. It is also produces a strong connection to the earth as such is an aid to connecting with the natural beauty of the planet [8].

2.2.4.4 Use in Perfumery

A base note and fixative par excellence. Patchouli oil is used in many famous perfumes such as Tabu and Shocking. A little patchouli oil, used as a fixative can be used in many natural perfume formulations. Patchouli oil mixes well with many essential oils including vetiver, sandalwood, frankincense, bergamot, cedarwood, myrrh, jasmine, rose and the citrus oils [8].

2.2.4.5 Other Uses

The essential oil is used as a room freshener, several drops added to the bath water, or applies on a handkerchief. The pure essential oil is very strong and can be tempered down by adding 10-20 drops of oil to 2 tablespoon of almond oil and 5 drops of wheat germ oil to preserve freshness. The oil is rubbed on pulse points,

temples or the mixture used as massage oil. It is also used to cool inflamed skin, and clear rough, cracked skin, sores, wounds and to treat minor skin disorders such as acne and dermatitis. Oil of patchouli is used in aromatherapy to clear lethargy and sharpen the wits. It is practical oil for releasing stress and tension in males. If a man wants to attract a woman, he could try patchouli perfume as a lure! Patchouli is cultivated extensively in India, Madagascar, Sumatra and the Seychelles for steam distillation of oil and used extensively in the manufacture of perfumes, incense, soaps, hair tonic, tobacco and cosmetics. Patchouli is known as one of the best fixatives in heavy perfumes. A fixative is a substance that helps the other ingredients hold their perfume longer. Its musty, earthy, scent is used as a base note in a third of all women's perfumes produced and half of men's perfumes [7].

2.2.5 Patchouli Extraction Oil

Patchouli (*Pogostemon cablin*) is an aromatic crop which yields an essential oil containing various sesquterpenes and hydrocarbons such as; patchouli alcohol (patchoulol), patchoulene, bulnesene, guaiene, caryophyllene, elemene and copaene [9-11]. The essential oil is one of the most important naturally occurring perfumery raw materials because of its characteristic woody fragrance and fixative properties by which the scent is fixed and make it last longer on the skin [12]. Areas of commercial cultivation are mainly located in Indonesia, which accounts for over 80% of world patchouli oil production [13].

2.2.6 Essential Oil Content

The leaves contain 1-3.5% of essential oil. Hence it requires around 29-100 kg of leaves to produce 1 kg of oil [14].

2.3 Plant Nutrition

2.3.1 Major Element

Fresh plant material is usually made up of between 80 and 95% water. So far, 16 elements have been identified as essential for plant growth. The plant cannot complete its life cycle without the element. Action of the element must be specific - no other element can take its place. The element must be directly involved (structure, constituent, enzyme activator, etc.). Three elements absorbed in large amounts from the air, water and soil are carbon (C), oxygen (O) and hydrogen (H) [15].

Plant concentrations of essential elements may exceed the critical concentrations, the minimum concentrations required for growth, and may vary somewhat from species to species. Nonetheless, Table 2.1 gives the general requirements of plants:

Table 2.1: Typical concentrations sufficient for plant growth[a] [16]

Element	Symbol	mg/kg	percent	Relative number of atoms
Nitrogen	N	15,000	1.5	1,000,000
Potassium	K	10,000	1.0	250,000
Calcium	Ca	5,000	0.5	125,000
Magnesium	Mg	2,000	0.2	80,000
Phosphorus	P	2,000	0.2	60,000
Sulfur	S	1,000	0.1	30,000
Chlorine	Cl	100	--	3,000
Iron	Fe	100	--	2,000
Boron	B	20	--	2,000

Table 2.1: Typical concentrations sufficient for plant growth[b] [16]

Element	Symbol	mg/kg	percent	Relative number of atoms
Manganese	Mn	50	--	1,000
Zinc	Zn	20	--	300
Copper	Cu	6	--	100
Molybdenum	Mo	0.1	--	1
Nickel	Ni	0.1	--	1

Table 2.2: Major element of plant nutrient[a]

Component	Sources	Deficiencies
Carbon	From carbon dioxide in the air. Converted into plant biomass by photosynthesis. All carbohydrates, proteins and fats are composed of a backbone of carbon atoms.	Not usually a proble. However, in a closed greenhouse in winter, or early in the morning before the vents open, plants can use up enough carbon dioxide to slow photosynthesis and reduce growth. Recommend: CO_2 generation.
Oxygen	From the air, and as part of water molecules (H_2O) and fertilizers (e.g., $MgSO_4$). Component of carbohydrates, proteins and fats; necessary for respiration	Can be a problem within the root zone root rot, and plant death.

Table 2.2: Major element of plant nutrient[b]

Component	Sources	Deficiencies
Hydrogen	From water and fertilizers as above. Component of carbohydrates, proteins and fats.	Usually not a problem.

2.3.2 Macronutrient

Six macro nutrients absorbed in large amounts from the soil or hydroponic solution that are nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulfur (S) [15].

Table 2.3: Macronutrient of plant nutrient[a]

Component	Sources	Deficiencies
Nitrogen	From fertilizers such as ammonium nitrate, potassium nitrate and/or calcium nitrate. Part of nucleic acids, chlorophyll and every "amino" acid and therefore every protein.	Restricted growth and yellowing (chlorosis) of older leaves.
Phosphorus	From fertilizers such as potassium phosphate. Part of the "energy currency" of cells (ATP, etc.), stimulates root/plant growth, maturity and blooming	Poor root/plant growth and flowering, "purplish" under leaves.

Table 2.3: Macronutrient of plant nutrient[b]

Component	Sources	Deficiencies
Potassium	From fertilizers such as potassium nitrate and potassium phosphate. Acts as a catalyst or activator of enzymes promotes overall growth, critical for stomata turgor.	Poor growth, leaf chlorosis/necrosis (death), slowed gas exchange.
Calcium	From fertilizers such as calcium nitrate. Primarily a cross-linking agent in cell walls. Also involved in acid/base regulation during metabolism and as an enzyme activator.	Poor growth of meristems (growing tip), blossom end rot.
Magnesium	From fertilizers such as magnesium sulfate. The "heart" of chlorophyll, and an activator for ATP/ADP metabolism, photosynthesis, respiration & DNA/RNA formation.	Interveinal chlorosis/necrosis of lower mature leaves.
Sulfur	From fertilizers such as magnesium sulfate or potassium sulfate. Part of 2 amino acids and therefore all proteins, forms sulfur bridges to establish and maintain protein structure.	Reduced growth in mid/young leaves, thin brittle stems.

2.3.3 Micronutrient

Seven micro nutrients absorbed in small amounts from the soil or hydroponic solution that are iron (Fe), manganese (Mn), boron (B), zinc (Zn), copper (Cu), molybdenum (Mo) and chlorine (Cl). Besides that, a number of other elements have

been found in plant tissue and are most likely required by some plants including sodium, silicon, cobalt, vanadium, iodine, bromine, fluorine, aluminum and nickel [15].

Table 2.4: Micronutrient of plant nutrient[a]

Component	Sources	Deficiencies
Iron	From ferrous sulfate, ferric chloride or iron chelate. Acts as a catalyst for enzymes involved in chlorophyll production, protein synthesis, respiration and other reactions.	Interveinal chlorosis of young leaves.
Manganese	From compounds such as manganese chloride. Involved in enzyme activation during carbohydrate reduction, chlorophyll and RNA/DNA synthesis and other reactions.	Interveinal chlorosis of young leaves, necrotic spots, leaf shed.
Boron	From compounds such as boric acid. Regulates carbohydrate metabolism; involved in RNA synthesis; probably related to the metabolism of calcium and potassium.	Poor growth, blackening then dies back of roots/shoots.
Zinc	From compounds such as zinc sulfate. Acts as an enzyme activator in protein, hormone and RNA/DNA synthesis and metabolism; aids in ribosome complex	General stunting esp. of young growth; interveinal chlorosis.

Table 2.4: Micronutrient of plant nutrient[b]

Component	Sources	Deficiencies
Copper	From compounds such as copper chloride. Involved in chlorophyll synthesis; part of the photosynthetic electron transport pathway and of several oxidases, etc.	Stunting, tip death, new leaf twist, blue-green leaves, necrosis, loss of turgor.
Molybdenum	From compounds such as molybdenum trioxide. Involved in nitrogen and carbohydrate metabolism.	Interveinal chlorosis, mottling and marginal scorching or inward cupping of older leaves.
Chlorine	From compounds such as copper chloride or manganous chloride. Acts as an enzyme activator during photosynthesis; involved in respiration; regulation of cell turgor; etc.	Older leaves chlorotic then necrotic; wilt; overall stunting.

2.3.4 Nutrient Solution

Optimum plant growth and yield are the goals, thus watering and nutritional supply is critical. Optimum nutrient solutions begin with good quality and quantity water. Before starting any commercial operation, the water must be analyzed. The source of water should be fairly neutral pH (5-8) with low salt and heavy metal content. Low of high pH can affect nutrient uptake and salt and metals can affect plant growth.

Optimum plant growth is a function of nutrient concentration in the plant. There is a critical nutrient concentration below which growth is reduced/terminated. The adequate zone is above the critical concentration and provides maximum

growth. The toxic zone is above the adequate zone, again resulting in reduced growth or death [15].

Nutrients are available in several forms, including pre-mixed liquid concentrates and pre-mixed powder concentrates varieties. In liquid concentrated form, calcium compounds are mixed separately from phosphates & sulfates since they will form insoluble precipitates and become unavailable to plants. The nutrient recipes vary according to types of crop, life stage, environmental conditions, time of year, etc.

2.4 Fertilizer

After the introduction of chemical fertilizers in the last century, farmers were happy of the increasement of yield in agriculture. Unfortunately, the chemical fertilizers started displaying their ill-effects such as leaching out, and polluting water basins, destroying micro-organisms and friendly insects, making the crop more susceptible to the attack of diseases, reducing the soil fertility and thus causing irreparable damage to the overall system [17].

A number of intellectuals throughout the world started working on the alternatives and found that biofertilizers can help in increasing the yield without causing much damage associated with chemical fertilizers.

2.4.1 Biofertilizer

The name itself is self explanatory. The fertilizers are used to improve the fertility of the land by using biological wastes, hence the term biofertilizers, and biological wastes do not contain any chemicals which are detrimental to the living soil. They are extremely beneficial in enriching the soil with those micro-organisms,

which produce organic nutrients for the soil and help combat diseases. The farm produce does not contain traces of hazardous and poisonous materials [17].

Biofertilizers are ready to use live formulates of such beneficial microorganisms which on application to seed, root or soil mobilize the availability of nutrients by their biological activity in particular, and help build up the micro-flora and in turn the soil health in general [18].

2.4.1.1 Why Should Use Biofertilizer

With the introduction of green revolution technologies the modern agriculture is getting more and more dependent upon the steady supply of synthetic inputs (mainly fertilizers), which are products of fossil fuel (coal+petroleum). Adverse effects are being noticed due to the excessive and imbalance use of these synthetic inputs. This situation has lead to identifying harmless inputs like biofertilizers. Use of such natural products like biofertilizers in crop cultivation will help in safeguarding the soil health and also the quality of crop products [18].

2.4.1.2 Benefit and Advantages Biofertilizer

Usage a biofertilizer helps to increase crop yield by 20-30% and replace chemical nitrogen and phosphorus by 25%. Besides that, it can activate the soil biologically and restore natural soil fertility. It can also provide protection against drought and some soil borne diseases [18].

Advantages from using a biofertilizer are cost effective firstly. Next it can be a supplement to fertilizer besides as an eco-friendly (friendly with nature). Biofertilizer also can reduce the costs towards fertilizers use, especially regarding nitrogen and phosphorus [18].

2.4.1.3 A Group of Component with a Particular Skill of Biofertilizer

Table 2.5: Component of biofertilizer[a]

Component	Function
Phospho	It releases insoluble phosphorus in soil and fix this phosphorus in clay minerals which is of great significance in agriculture [17].
Rhizo	Rhizo Bacterial plays a very important role in agriculture by inducing nitrogen fixings nodules on the root of legumes such as peas, beans clove and alfalfa.
Azobactor	Atmosphere contains 78% nitrogen which is a very important nutrient for plant growth. Azotobactor fixes the atmospheric nitrogen in the soil and make it available to the plants. It protects the roots from other pathogens present in the soil.
Trichoderma	It is a non- pathogenic and eco-friendly product. The product is antagonistic hyper parasitic against different pathogens in the field and economically well established biocontrol agent.
Tricho-Card	Trichogramma is an efficient destroyer of eggs of many leaf and flower eaters, stems, fruit, shoot borers etc. It can be used in a variety of crops as well as in horticultural and ornamental plants, such as sugarcane, cotton, brinjal, tomato, corn, jawar, vegetables, citrus, paddy apple etc.
Vermi Compost	It is 100% pure eco-friendly organic fertilizer. This organic fertilizer has nitrogen phosphorus, potassium, organic carbon, sulphur, hormones, vitamins, enzymes and antibiotics which help to improve the quality and quantity of yield. It is observed that due to continuous misuse of chemical fertilizer soil losses its fertility and gets salty day by day. To overcome such problems natural farming is the only remedy and Vermi compost is the best solution.

Table 2.5: Component of biofertilizer[b]

Component	Function
Biocompost	It is eco-friendly organic fertilizer which is prepared from the sugar industry waste material which is decomposed and enriched of with various plants and human friendly bacteria and fungi. Biocompost consists of nitrogen, phosphate solubilizing bacteria and various useful fungi like decomposing fungi, *Trichoderma viridea* which protects the plants from various soils borne disease and also help to increase soil fertility which results to a good quality product.

2.4.2 Organic Fertilizer

Organic fertilizers differ from chemicals fertilizers. Organic fertilizer will feed the plants by adding organic material to the soil. Soils with lots of organic matter remain loose and airy, hold more moisture and nutrients, foster growth of soil organisms, and promote healthier plant root development. If only chemicals are added the soil gradually loses its organic matter and microbiotic activity. As organic matter is used up, the soil structure deteriorates, becoming compact, lifeless and less able to hold water and nutrients. An organic fertilizer is eco-friendly because it made from renewable resources [18].

This organic fertilizer is unequaled in its ability to nourish the beneficial micro-organisms in the soil greatly increasing the soil's humus content and improving its ability to sustain and nurture healthy, when planting flower beds or spread it around established plants and scratch it into the soil, more colorful plants. Use by the handful when planting individual plants, broadcast and mix it deeply into the soil.

There are millions of microscopic organisms near the plants that consist in a micro environment that provides nutrients to the plants and also it helps to keep the water and retain the nutrients in the soil for a plants uses [19].

When fill it with chemicals fertilizer, most of microscopic organisms will die forever and losing the capacity of the soil to be sustainable at long term.

2.4.2.1 Benefit Offers by Organic Fertilizer

Organic fertilizer is an easy product to apply to the plant. By using organic fertilizer also, it is excellent for pest and disease tolerance because at the same time it can protect plants. It is safe to use, non-toxic and extremely universal. It mean that organic fertilizer is safe for a children or any pets and can be apply to any plant in a yard [19]. Besides that, the result from using an organic fertilizer can be observed immediately. Organic fertilizer also is tremendous drought resistance by enhances plant root systems. Finally, it is unbeatably cost effective and user doesn't have to spend a fortune for a beautiful lawn and garden.

2.5 Patchouli Essential Oil Production

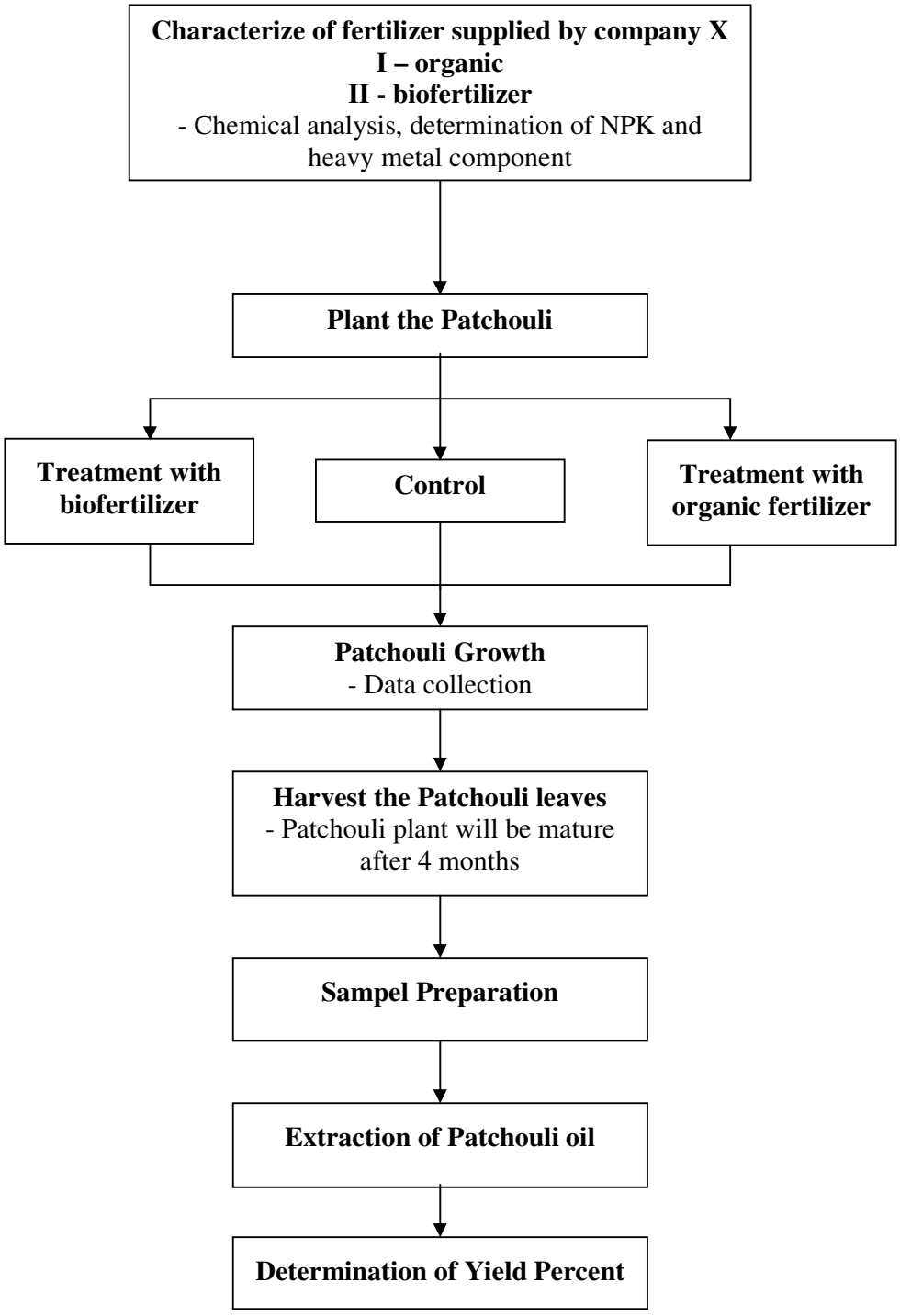

Figure 2.2: Overall process in production patchouli oil through hydrodistillation

CHAPTER 3

METHODOLOGY

3.1 Introduction

In order to plant the patchouli (*Pogostemon cablin*), the simplest step, like medium preparation, plant the patchouli's young, sprinkle with water and applying the fertilizer must be done before extraction process can be take place. In this experiment, 28 patchouli plants were used. Organic and biofertilizer is used as nutrients for the patchouli to growth well. The component of organic and biofertilizer also will be characterized first before apply it into the patchouli.

3.2 Pre-preparation

3.2.1 Preparation of Planting Area

All the patchouli will be planted in a suitable area to keep it growth within a good condition. 28 patchouli plants (planted in ceramic vases) were used in this study. All the ceramic vases will be arranged properly in a group and located in an open area.